

### **Remarks/Arguments**

Upon entry of the foregoing amendments, claims 46 – 64 will be pending in this patent application. Claims 1-45 were cancelled in a previous response. Claims 47 – 48 and 50 are canceled herein without prejudice. Claim 46, 49, and 51 – 55 are amended herein.

In the previous Office Action dated August 9, 2007, which was issued by a different Examiner, Applicants were required to elect a single disclosed species of its claimed invention. In their response dated October 9, 2007, Applicants traversed the election of species requirement by submitting new claims that reflected the elected species. The present Office Action does not discuss nor comment upon Applicants' traversal. Applicants' would like to reinstate the claimed subject matter if the election of species requirement was removed.

#### *I. Amendments to the Specification:*

In page 2 of the Office Action, the Examiner requested that Applicants amend the abstract. The Examiner's request that applicant amend the abstract is respectfully traversed. Such an amendment would narrow the technical description of Applicants' disclosure. The U.S. Court of Appeals for the Federal Circuit has expressly held in *Hill-Rom Co. v. Kinetic Concepts, Inc.*, 54 USPQ2d 1437, 209 F.3d 1337 (Fed. Cir. 2000) that the description in the abstract could, would and did provide a basis for a narrowing construction of a claim; and this was done to the patentee's disadvantage, i.e., the claim was held narrower than its literal language (even though free of the prior art without that narrowed scope) which resulted, as a consequence, in a holding of non-infringement. Rule 1.72(b) and MPEP § 608.01(b) oblige Applicants to provide a technical description of the disclosure in a brief abstract. Applicants have done so. Further, Applicants disagree with the Examiner's suggestion for amending the abstract to reflect a method because the abstract as it is currently written does include one or more embodiments of processes described within the disclosure.

The Examiner has requested that the title be amended to reflect the claimed inventions. Applicants have amended the title accordingly.

The disclosure is objected to because on page 1, paragraph [0001], the related application need to be updated to reflect that the related application is now issued U.S. patent U. S. Pat. No. 7,311,946. Applicants have done so.

*II. Amendments to the Claims:*

In the present response, new claims 56 – 64 are added herein. It is submitted that new claims 56– 60 raises no new issues and does not require the Examiner to conduct an additional search, since the claim merely clarifies the subject matter previously presented. Support for claim 56 is provided, for example, in paragraphs [0021], [0037], Example 7, Example 9 and original claims 42 and 44. Support for claim 57 is provided, for example, in paragraphs [0021], [0037], Example 10 and original claims 42 – 43. Support for claim 58 is provided, for example, in paragraphs [0037] and [0041]. Support for claim 59 is provided, for example, in paragraphs [0037] and [0041]. Support for claim 60 is provided, for example, in paragraphs [0037] and [0041]. Support for claims 61 – 64 is provided, for example, in original claims 42 – 45. Applicants respectfully request entry of the new claims.

Claim 46 is amended herein to add the recitation “selected from the group consisting of a (111) preferred orientation and a (100) preferred orientation”. The amendment clarifies subject matter previously before the Examiner. Support for the recitation is provided, for example, in paragraph [0026], [0037], Examples 7, 9, and 10, and original claims 42 – 44. No new matter is being introduced in entering the new amendment. Applicants respectfully request entry of the amendment.

Claim 55 is amended to recite that the surface of the diffusion barrier layer “is selected from a non-stoichiometric surface comprising a lesser amount of nitrogen atoms than tungsten atoms contained therein, an amorphous surface, a polycrystalline surface, a stoichiometric surface having a preferred orientation other than a (100) orientation, a stoichiometric surface having a preferred orientation other than a (111) preferred orientation, and combinations thereof”. Support for the recitation is provided, for example, in paragraph [0031]-[0033], [0035]-[0037], and [0041]. No new matter is being introduced in entering the new amendment. Applicants respectfully request entry of the amendment.

*III. Written Description Rejections:*

Claims 46-55 were rejected under 35 U.S.C. § 112, para. 2 as allegedly being indefinite for “failing to particularly point out and claim the subject matter which Applicant regards as the invention.” Claims 47 – 54 were rejected because the claims were dependent on canceled claim 42. Claims 47 – 48 and 50 are canceled herein. Claims 49 and 51 – 54 were amended herein to change their dependency from canceled claim 42 to amended claim 46. No new matter is being entered herein. Further claim 49 was amended to recite “at least

one" with regard to surface. Applicants respectfully request entry of the amendments. Applicants respectfully request removal of the 112 rejections of the claim.

Claim 51 has been rejected under 35 USC § 112, para. 2 as allegedly being indefinite. With regard to the differences between "plasma enhanced CVD" and "plasma assisted CVD" and "thermal CVD" and "chemical assisted CVD", Applicants maintain that these particular embodiments of CVD processes should remain because they are recognizable to one of skill in the art. Further, the phrase "and combinations thereof" is deemed vague and indefinite. Applicants disagree. Applicants' specification states, for example, at page 13, [0038] that "[t]hese processes may be used alone or in combination." Further, a claim may not be rejected solely because of the type of language used to define the subject matter for which patent protection is being sought. *In re Swinehart*, 439 F.2d 210, 160 USPQ 226 (CCPA 1971). If the claims, read in light of the specification, reasonably apprise those skilled in the art both of the utilization and scope of the invention, and if the language is as precise as the subject matter permits, 35 USC § 112, ¶ 2 demands no more. *Shatterproof Glass Corp. v. Libbey Owens Ford Co.*, 758 F. 2d 613, 225 USPQ 634 (Fed. Cir. 1985). Applicants maintain that the terms in claim 51 are sufficiently clear in view of the specification. Support for the terms is provided, for example, in the specification at paragraph [0038], [0043], and [0048]. Applicants respectfully request removal of the 112 rejections of the claim.

#### *IV. The Claimed Invention*

Amended claims 46 and 55 and the claims that depend therefrom provide processes that allow one to form a substantially continuous metal film on the surface of a diffusion barrier layer comprising tungsten nitride such that the metal film may have an increased adherence to the underlying barrier layer. Organometallic precursors and dissociated species thereof are extremely reactive to free metal present in the diffusion barrier layer (see, for example, Applicants' specification at paragraphs [0029]-[0030]). The dissociated species may react with the exposed metal leading to the formation of a fluorine, carbon, and oxygen containing amorphous layer between the metal film and the barrier layer (*id.* at paragraph [0029]). The formation of this amorphous layer may compromise the adhesion between the metal and barrier layer (*id.*). The claimed invention solves this problem of reactivity by rendering the barrier layer substantially unreactive towards the organometallic precursor or dissociated species thereof (*id.* at [0032]).

In the embodiment of claim 46, the tungsten nitride diffusion barrier layer "comprises a stoichiometric amount or greater of nitrogen relative to tungsten contained therein" and has an orientation that is "selected from the group consisting of a (111) preferred orientation and a (100) preferred orientation" (*id.* at [0026], [0037] and Examples 7, 9, and 10). Example 8 demonstrates that copper cannot be deposited onto a tungsten diffusion barrier layer having a (100) preferred orientation because the surface of the barrier layer had exposed tungsten metal (*id.* at Example 8 and [0073]-[0074]). By contrast, Examples 7, 9, and 10 demonstrate that copper can be adherently deposited onto a stoichiometric tungsten nitride diffusion barrier layer having a substantially (111) preferred orientation, a (111) preferred orientation, and a (100) preferred orientation, respectively, because the organometallic precursor or dissociated species thereof are not exposed directly to exposed tungsten metal during the deposition and avoids the formation of the fluorine, carbon, and oxygen containing amorphous layer (*id.* at Example 7 and [0071]-[0072], Example 9 at [0077]-[0079], and Example 10 at [0082]).

In the embodiment of claim 55, the tungsten nitride diffusion barrier layer "is selected from a non-stoichiometric surface comprising a lesser amount of nitrogen atoms than tungsten atoms contained therein, an amorphous surface, a polycrystalline surface, a stoichiometric surface having a preferred orientation other than a (100) orientation, a stoichiometric surface having a preferred orientation other than a (111) preferred orientation, and combinations thereof" (*id.* at [0037] and [0041]). In other words, the tungsten barrier layer does not have a substantially preferred (111) orientation, (111) preferred orientation, (100) preferred orientation, or has less than a stoichiometric amount of nitrogen relative to tungsten contained therein, the surface is exposed to "an at least one adhesion promoting agent comprising nitrogen" (*id.*). The step of exposing to the at least one adhesion promoting agent renders the barrier layer substantially unreactive towards the organometallic precursor or dissociated species thereof (*id.* at [0032]-[0033] and [0044]).

#### V. The Prior Art Rejections:

Claims 46, 51, and 54 stand rejected under 35 U.S.C. § 102(a) as allegedly being anticipated by, or in the alternative allegedly rendered obvious under 35 U.S.C. § 103(a), by the U.S. Pat. No. 6,413,864 ("Pyo"). Applicants respectfully disagree. For a prior art reference to be anticipatory, MPEP § 2131 provides that: "A claim is anticipated only if each

and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference.” *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628 (Fed. Cir. 1987). Further, the reference has to describe each and every element recited in the claim in as complete detail as is contained in the claim and arranged as recited in the claim. (“The identical invention must be shown in as complete detail as contained in the ... claim.” *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226 (Fed. Cir. 1989)).

Applicants respectfully traverse the §102(a) or 103(a) rejections of the claims by Pyo because Pyo does not disclose every limitation required in the claims nor describe every limitation in as complete detail and arranged as recited in the claims. While Pyo describes a tungsten nitride barrier layer 15 and one or more copper layers 18 and 19 that are deposited by a CVD method, Pyo fails to describe tungsten nitride barrier layers that are comprised of an orientation “selected from the group consisting of a (111) preferred orientation and a (100) preferred orientation” and “forming a metal film...on the at least one surface” of the diffusion barrier layer as required in Applicants’ claim 46 and the claims that depend therefrom. Instead, Pyo describes a diffusion barrier layer (15) which has a 5 to 500 Å thick seed layer (16) containing titanium (Ti), aluminum (Al) or copper formed thereupon (see Pyo at col. 2, lines 55 – 67 and col. 3, lines 1-2 and Fig. 1B). Referring to Fig. 1C, a chemical enhancement layer is then formed by conducting a chemical enhancer treatment that involves contacting the substrate with an iodine-containing liquid compound (see *id.* at col. 3, lines 3-35 and Fig. 1C and 1D). The first copper layer 18 is then deposited upon the chemical enhancer layer 17 (see *id.* at col. 3, lines 36-41, claim 1 and Fig. 1E) rather than on the surface of the diffusion barrier layer. Because Pyo fails to teach or suggest all of the required elements of claim 46 and the claims that depend therefrom, Pyo fails to neither anticipate nor render obvious Applicants’ claimed invention. Applicants respectfully request that the prior art rejections of the claims by Pyo be removed.

Claims 46, 51, and 54 stand rejected under 35 U.S.C. § 102(a) as allegedly being anticipated by, or in the alternative allegedly rendered obvious under 35 U.S.C. § 103(a), by the U.S. Publ. Appl. No. 2002/0053519 (“*Morrissey et al.*”). Applicants respectfully disagree. Like Pyo, *Morrissey et al.* fails to teach or suggest all of the required elements of claim 46 and the claims that depend therefrom. *Morrissey* fails to teach, *inter alia*, tungsten nitride barrier layers that are comprised of an orientation “selected from the group consisting of a (111) preferred orientation and a (100) preferred orientation” and “forming the metal film via a chemical vapor deposition process on the at least one surface using at least one

organometallic precursor comprising copper". Instead of depositing the copper layer by chemical vapor deposition, Morrissey et al. discloses the use of an electroplating bath to deposit a copper seed layer that is substantially free of discontinuities or voids (see Morrissey et al., for example, at [0021] and [0045]). Morrissey et al. discusses the general use of tungsten nitride as a barrier layer to prevent migration of copper into the dielectric layer and the use of physical vapor deposition or chemical vapor deposition to deposit copper seed layers (see *id.* at [0004] – [0005]). However, Morrissey et al. may teach away from the deposition of a seed layer of copper onto an unspecified surface by stating that "[s]uch metal seed layers, particularly copper seed layers, may suffer from problems such as metal oxide both on the surface of the seed layer and in the bulk of the layer as well as significant variations in the thickness of discontinuities in the layer" (see *id.* at [0005]). Because Morrissey et al. fails to teach or suggest all of the required elements of claim 46 and the claims that depend therefrom, Morrissey et al. fails to neither anticipate nor render obvious Applicants' claimed invention. Applicants respectfully request that the prior art rejections of the claims by Morrissey et al. be removed.

Claims 52-53 and 55 stand rejected as allegedly rendered obvious under 35 U.S.C. § 103(a) over Morrissey et al. or Pyo. Applicants respectfully disagree. Claims 52-53 contain all of the elements of claim 46. As previously discussed, neither Morrissey et al. nor Pyo alone or in combination teach nor suggest all of the required elements of Applicants' invention in claim 46 and claims 52-53 which depend therefrom. Further, neither Morrissey et al. nor Pyo describe, *inter alia*, the recitation "exposing the surface of the diffusion barrier layer to an at least one adhesion promoting agent comprising nitrogen" in claim 55. Applicants respectfully request that the prior art rejections of the claims by Morrissey et al. alone or in combination with Pyo be removed.

Claim 49 stands rejected as allegedly rendered obvious under 35 U.S.C. § 103(a) over Morrissey et al. or Pyo when either is taken in view of U.S. Pat. No. 6,150,268 ("Iacoponi et al."). Applicants respectfully disagree. Claim 49 contains all of the elements of claim 46. As previously discussed, neither Morrissey et al. nor Pyo alone or in combination teach nor suggest all of the required elements of Applicants' invention in claim 46 and claims 49 which depends therefrom. Further, Iacoponi et al. fails to provide the missing teachings. For example, Iacoponi et al. fails to teach or suggest a tungsten nitride barrier layer wherein the at least one surface of the barrier layer has an orientation "selected from the group consisting of a (111) preferred orientation and a (100) preferred orientation". Iacoponi et al.

teaches tungsten nitride barrier layers having increased nitrogen content (e.g., having between 40% and 60% nitrogen content by atomic concentration) to provide "improved barrier effectiveness to copper diffusion" rather than adherence to an overlying metal or copper layer (see Iacoponi et al. at col. 5, lines 6-22). On another note, Iacoponi et al. does discuss depositing a Ta adhesion layer or "conductive barrier layer" onto the silicon substrate prior to depositing the WN barrier layer onto the underlying silicon substrate to provide a combined adhesion/barrier layer or "associated structure" (see *id.* at col. 5, lines 65-67, col. 6, lines 51-55 and Fig. 2). According to Iacoponi, the associated structure containing the Ta adhesion layer – not the nitrogen enriched WN barrier layer alone- improves the texture of the overlying copper layers (see *id.* at col. 3, lines 52-55 and col. 3, lines 23-35). Because Morrissey et al., Pyo, and Iacoponi et al. alone or in combination fail to teach or suggest all of the required elements of Applicants' claim 49, Applicants respectfully request that the prior art rejections of the claim be removed.

*VI. Conclusion:*

Applicants believe that the foregoing constitutes a complete and full response to the Action of record. Applicants respectfully submit that this application is now in condition for allowance. Accordingly, an indication of allowability and an early Notice of Allowance are respectfully requested.

The Commissioner is hereby authorized to charge the fee required and any additional fees that may be needed to Deposit Account No. 01-0493 in the name of Air Products and Chemicals, Inc.

Should the Examiner require any further information, the Examiner is invited to contact Applicants' undersigned Attorney at the telephone number listed below.

Respectfully submitted,

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